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A Levitation Device of the Floor of the Elevator Enclosure Car
[エレベーターかご室床の浮上装置]

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[What is Claimed is:]

[Claim 1]

A levitation device of the floor of the elevator enclosure car, characterized in that said levitation device is comprised of:

an elevator enclosure car frame, which moves up and down along guide rails;

an enclosure car, which is created inside said enclosure car frame and comprised of a bottom part and a side wall part, which are separable; and

an electromagnet, which is placed between the side wall part of said enclosure car mounted on said enclosure car frame and the bottom part of said enclosure car and maintains a non-contact state, wherein said bottom part is not contacted with said enclosure car frame, by using the electromagnetic force.

[Claim 2]

The levitation device as set forth in clam 1 of the floor of the elevator enclosure car, characterized in that said levitation device is further comprised of an elastic body, which is placed between the bottom part of said enclosure car and the enclosure car frame and elastically supports said bottom part when said electromagnet is not used.

[1] Numbers in the margin display pagination in the foreign text.

[Claim 3]

The levitation device as set forth in clam 1 of the floor of the elevator enclosure car, characterized in that said electromagnet is comprised of a longitudinally-magnetized electromagnet, which vertically levitates said bottom part and a transversally-magnetized electromagnet, which horizontally separates said bottom part from said enclosure car frame.

[Claim 4]

The levitation device as set forth in clam 1 or 3 of the floor of the elevator enclosure car, characterized in that said electromagnet is positioned so that force of electromagnetic attraction or that of electromagnetic repulsion is used.

[Claim 5]

The levitation device as set forth in clam 1 or 3 of the floor of the elevator enclosure car, characterized in that said levitation device is further comprised of an electromagnet control means, which controls the electromagnetic force of said electromagnet and adjusts a gap between said bottom part and said enclosure car frame.

[Claim 6]

The levitation device as set forth in clam 5 of the floor of the elevator enclosure car, characterized in that said levitation device is further comprised of a gap sensor, which detects the gap between said bottom part and said enclosure car frame, and said electromagnet control

means controls the electromagnetic force of said electromagnet so that vibration of said bottom part is decreased according to the detected output of said gap sensor.

[Claim 7]

The levitation device as set forth in clam 5 of the floor of the elevator enclosure car, characterized in that said levitation device is further comprised of vibration detection means, which detects vibration of said bottom part, and said electromagnet control means controls the electromagnetic force of said electromagnet so that vibration of said bottom part is decreased according to the detected output of said vibration detection means.

[Claim 8]

The levitation device as set forth in clam 7 of the floor of the elevator enclosure car, characterized in that said vibration detection means is comprised of an acceleration sensor.

[Claim 9]

The levitation device as set forth in clam 7 of the floor of the elevator enclosure car, characterized in that said levitation device is further comprised of a gain-phase adjuster, wherein the detected output from said vibration detection means is inputted, and the output of said gain-phase adjuster is inputted in said electromagnet control means.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a levitation device of the floor of the elevator enclosure car, which levitates the floor of the enclosure car, which is created separately from the side walls of the enclosure car of an elevator.

[0002]

[Prior Arts]

The enclosure car is created inside the enclosure car frame and the enclosure car frame is moved along the guide rails so that the enclosure car moves up and down. Therefore, if the accuracy of laying the guide rails is inferior, the enclosure car is vibrated through the guide rails, or the pulsing motion of the motor torque and the like is transmitted from the enclosure car frame to the enclosure car through the rope thereby vibrating the enclosure car. To prevent the vibration, generally, an elastic body such as antivibration rubber is placed between the bottom part of the enclosure car and the bottom part of the enclosure car frame so that the mechanical vibration is not transmitted to the enclosure car. However, since the vibration frequency, which is transmitted from the rope or guide roller to the enclosure car, ranges from a few Hz to tens of Hz, it is difficult to decrease all the vibration only by using the elastic body such as antivibration rubber. Therefore, conventionally, various methods have been proposed. Among them, Japanese unexamined published

application No. Sho 63-306183 discloses a method, wherein antivibration rubber and an electromagnet are placed together and the electromagnet is actively used so as to eliminate the transmitted vibration. Also, Japanese unexamined published application No. Hei 1-156293 discloses a method wherein the entire enclosure car is levitated from the enclosure car frame.

[0003]

[Problems to be Solved by the Invention]

According to the above described first method, an electromagnet is placed on antivibration rubber and reversed-phase vibration of the vibration, which is transmitted to the antivibration rubber, is given to the antivibration rubber so that no vibration is transmitted to the enclosure car. However, since the enclosure car frame is mechanically connected to the enclosure car through the antivibration rubber, it cannot help that vibration is transmitted from the rope or guide roller to the enclosure car. Similarly, according to the above described latter method, since the enclosure car vibrates following the enclosure car frame, it is possible to significantly decrease the transmission of vibration. However, it is not possible to effectively decrease vibration with a low frequency. Furthermore, to levitate the entire enclosure car with heavy weight, it is necessary to obtain high energy. As a result, the size of the device is increased, which naturally makes the cost increase. In either of the above

described cases, the ride comfort of the passengers is not satisfactory.

[0004]

The present invention was created based on the above described situation of the conventional technologies. The first objective of the present invention is to provide a levitation device of the elevator enclosure car, which can effectively prevent transmission of vibration from the enclosure car frame to the enclosure car thereby providing an elevator with good riding comfort. The second objective of the present invention is to decrease the size of the above described levitation device so as to provide the device at low cost.

[0005]

[Means to Achieve the Objectives]

To achieve the above described objectives, according to the present invention, the levitation device of the floor of the elevator enclosure car is characterized in that said levitation device is comprised of:

an elevator enclosure car frame, which moves up and down along guide rails;

an enclosure car, which is created inside said enclosure car frame and comprised of a bottom part and a side wall part, which are separable; and

an electromagnet, which is placed between the side wall part of said enclosure car mounted on said enclosure car frame and the bottom part of said enclosure car and maintains a non-contact state, wherein said bottom part is not contacted with said enclosure car frame, by using the electromagnetic force.

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[0006]

In this case, it is preferable that said electromagnet is comprised of a longitudinally-magnetized electromagnet, which vertically levitates said bottom part and a transversally-magnetized electromagnet, which horizontally separates said bottom part from said enclosure car frame. Also, it is preferable that the electromagnetic force of said electromagnet can be controlled by an electromagnet control means and a gap between said bottom part and said enclosure car frame can be controlled by said electromagnet control means. It is preferable that a gap sensor, which detects a gap between said bottom part and said enclosure car frame, is created to control said gap. Also, the detected output of said gap sensor can be inputted in said electromagnet control means and the electromagnetic force of said electromagnet can be controlled by said electromagnet control means so that vibration of said bottom part is decreased. Furthermore, a vibration detection means, which detects vibration of said bottom part, is created, and said

electromagnet control means can control the electromagnetic force of said electromagnet so that vibration of said bottom part is decreased according to the detected output of said vibration detection means.

[0007]

[Mechanism of the Invention]

With the above described structure, the bottom part of the enclosure car can be supported by the electromagnetic force of the electromagnet through an interspace existing between said bottom part and said enclosure car frame. As a result, it is possible to significantly decrease the mechanical vibration, which is directly transmitted from the enclosure car frame and guide rails. Also, the electromagnetic control means retrieves the detected output from the gap sensor and a signal detection means and the like and controls the electromagnetic force of the electromagnet so as to decrease vibration of the bottom part. As a result, vibration, which is felt by the passengers in the enclosure car, is significantly decreased thereby increasing the riding comfort. Furthermore, since all that is necessary is to levitate the weight of the bottom part of the enclosure car and the weight of the passengers, the size of the levitation device can be smaller and lesser consumption energy is required.

[0008]

[Description of the Embodiment]

Next, an embodiment of the present invention will be described by using the drawings. Figure 1 is a view illustrating the details of the levitation device of the enclosure car of an elevator according to the present embodiment. Figure 2 is a view illustrating the skeleton framework of the relationship among the enclosure car, enclosure car frame and levitation device. In Figure 2, enclosure car 1 of the elevator is created inside enclosure car frame 2 and ropes 3 are connected to the upper part of enclosure car frame. Enclosure car frame 2 is lifted by ropes 3 and mounted on guide rails (not shown in the figure) so that enclosure car frame 2 can move along said guide rails. Enclosure car 1 is comprised of floor (bottom part) 4 of the enclosure car and side walls (side wall part) 5 of the enclosure car. Both floor 4 and side walls 5 are movably separated.

[0009]

Antivibration rubber 7, which is made from an elastic body, is created on bottom plate 6 of enclosure car 2. As shown in Figure 1, bottom part supporting plate 8 of side walls 5 of the enclosure car is fixedly placed on said antivibration rubber 7. In other words, bottom part supporting plate 8 bulges from the surface of the bottom part of side walls 5 of the enclosure car in the horizontal direction. Said bottom part supporting plate 8 is mounted on antivibration rubber 7. Floor

4 of the enclosure car is placed on bottom part supporting plate 8. As is obvious from Figure 1, a bracket 9, which has a U-letter shape when viewed from the side (hereinafter called "longitudinal bracket") and traverses bottom part supporting plate 8 of side walls 5 of the enclosure car, is extended from floor 4 of the enclosure car. Gap sensor 11 (hereinafter called "longitudinal gap sensor") for detecting a gap between electromagnet 10, which vertically operates (hereinafter called "longitudinal electromagnet"), and bottom plate 6 of enclosure car frame 2 is placed on horizontal part 9a of the lower side of longitudinal bracket 9. Also, bracket 13 (hereinafter called "traverse bracket"), which supports electromagnet 12, which horizontally operates (hereinafter called "traverse electromagnet"), is vertically created in the place, which externally faces the vertical part of said bracket 9 of bottom plate 6 of enclosure car frame 2. Gap sensor 14 (hereinafter called "traverse gap sensor"), which detects a gap between said traverse bracket 13 and said longitudinal bracket 9, is created on traverse bracket 13. In addition to said longitudinal bracket 9, floor 4 of the enclosure car has acceleration sensor 15, which detects the acceleration in the vertical direction (hereinafter called "longitudinal acceleration sensor"), and acceleration sensor 16, which detects the acceleration in the horizontal direction (hereinafter called "traverse acceleration sensor").

[0010]

The output of longitudinal acceleration sensor 15 is inputted in gain-phase adjuster 17 (hereinafter called "longitudinal gain-phase adjuster") and the output of gain-phase adjuster 17 is inputted in electromagnet control device 18 (hereinafter called "longitudinal electromagnet control device), which is used as the electromagnet control means. Also, the output of longitudinal gap sensor 11 is added to the output of a command from gap commanding part 19 (hereinafter called "longitudinal gap commanding part") in adder 20 (hereinafter called "longitudinal adder") and inputted in longitudinal electromagnet control device 18. Then, a control signal is outputted from longitudinal electromagnet control device 18 to longitudinal electromagnet 10.

[0011]

Similarly, the output of traverse acceleration sensor 16 is inputted in traverse gain-phase adjuster 21 and the output of gain-phase adjuster 21 is inputted in traverse electromagnet control device 22. Also, the output of traverse gap sensor 14 is added to the output of a command from traverse gap commanding part 23 in traverse adder 24 and inputted in traverse electromagnet control device 22. Then, a control signal is outputted from traverse electromagnet control device 22 to traverse electromagnet 12. Here, each of the above described structural components including longitudinal and traverse

electromagnets 10 and 12 is symmetrically placed on both sides of floor 4 of the enclosure car. Also, naturally, these structural components may be placed on parts corresponding to four corners of floor 4 of the enclosure car.

[0012]

According to the levitation device with the above described structure, in the state wherein no electromagnetic force is generated because no electricity is turned on longitudinal electromagnet 10, gap $\delta 1$ between floor 4 of the enclosure car and antivibration rubber 7 is zero and, as in the case of the conventional device, enclosure car 1 is connected to enclosure car frame 2 through antivibration rubber 7. In other words, enclosure car 1 is supported by enclosure car frame 2 through antivibration rubber 7. Therefore, even in the state wherein longitudinal electromagnet 10 is not in operation, it is possible to normally operate the levitation device.

[0013]

On the other hand, when electricity is turned on longitudinal electromagnet 10 and a predetermined electromagnetic force is generated by longitudinal electromagnet control device 18, longitudinal electromagnet 10 attracts bottom plate 6 of enclosure car frame 2 and longitudinal bracket 9 is moved so as to balance with the weight of floor 4 of the enclosure car and the load applied to floor 4.

Consequently, gap δ2 between bottom plate 6 of enclosure car frame 2 and longitudinal electromagnet 10 is changed. As a result, floor 4 of the enclosure car is separated from antivibration rubber 7 and levitated thereby producing gap δ1 between bottom part supporting plate 8 of side walls 5 of the enclosure car, which are positioned on the upper surface of antivibration rubber 7, and longitudinal bracket 9, that is, gap δ1 between bottom part supporting plate 8 and floor 4 of the enclosure car. In this way, since floor 4 of the enclosure car is mechanically separated from side walls 5 of the enclosure car and enclosure car frame 2, transmission of the vibration is decreased. Furthermore, if the force of electromagnetic attraction of longitudinal electromagnet 10 is controlled so that said gap δ2 becomes constant as opposed to variation of load of floor 4 of the enclosure car, it is possible to stabilize floor 4 of the enclosure car and effectively prevent the vibration. Therefore, longitudinal gap sensor 11 and traverse acceleration sensor 15 are created so as to control the electromagnetic force of longitudinal electromagnet 10 in accordance with vibration in the longitudinal direction.

[0014]

In other words, the target value of the gap, which is commanded by longitudinal gap commanding part 19, and the detected value of gap

$\delta 2$ between bottom plate 6 of enclosure car frame 2 and longitudinal electromagnet 10 are inputted in longitudinal adder 20. Then, according to the deviation, longitudinal electromagnet control device 18 controls the electromagnetic force of longitudinal electromagnet 10 so that the value of gap $\delta 2$ is the above described target value. Also, small vibration of floor 4 of the enclosure car is detected by longitudinal acceleration sensor 15 and the detected signal is transmitted to longitudinal electromagnet control device 18. Then, longitudinal electromagnet control device 18 controls the electromagnetic force of longitudinal electromagnet 19 so as to eliminate the vibration of floor 4 of the enclosure car. As a result, it is possible to effectively decrease the vibration of floor 4 of the enclosure car. Furthermore, to further effectively decrease the vibration of floor 4 of the enclosure car, according to the present embodiment, longitudinal gain-phase adjuster 17 is created between longitudinal acceleration sensor 15 and longitudinal electromagnet control device 18. By creating longitudinal gain-phase adjuster 17 in this way and appropriately setting the constant number of longitudinal gain-phase adjuster 17, it is possible to further effectively decrease the signal of floor 4 of the enclosure car. Here, the constant number of longitudinal gain-phase adjuster 17 is changed in accordance with the load of floor 4 of the enclosure car and the running position of the enclosure car. With the above described

structure, the vibration of floor 4 of the enclosure car is more demonstrably decreased against vibration, which is changed based on conditions such as the number of passengers and the length of the ropes.

[0015]

With the above described structure, vibration in the vertical direction can be effectively decreased by longitudinal electromagnet 10. However, this structure is not stable against vibration in the horizontal direction. Therefore, to prevent the vibration in the horizontal direction, the same antivibration rubber as the above described one may be created between floor 4 of the enclosure car and enclosure car frame 2. However, it is not possible to effectively decrease the vibration with the same reason as the above described one. Therefore, according to the present embodiment, traverse electromagnet 12, which is similar to longitudinal electromagnet 10, is created in the side of enclosure car frame 2. Traverse gap sensor 14, traverse acceleration sensor 16, traverse gain-phase adjuster 21, traverse gap commanding part 23 and traverse adder 24, which have the similar functions as those of each structural components used for controlling vibration in the longitudinal direction, are created. By using gap δ3 between enclosure car frame 2 and longitudinal bracket 9 in the side of floor 4 of the enclosure car and traverse acceleration sensor 16, vibration in the horizontal direction is prevented in the

manner similar to the above described method used for vibration in the longitudinal direction.

[0016]

Here, according to the present embodiment, bottom plate 6 of side walls 5 of the enclosure car is fixedly placed on antivibration rubber 7. However, side walls 5 of the enclosure car may be fixed to enclosure car frame 2 and floor 4 of the enclosure car may be levitated from enclosure car frame 2. Here, in this case, vibration of side walls 5 of the enclosure car is increased.

[0017]

Figure 3 is an enlarged view of the main part of another embodiment of the present invention. According to the present embodiment, longitudinal electromagnet 10 is placed facing both bottom plate 6 of enclosure car frame 2 and floor 4 of the enclosure car and traverse electromagnet 12 is placed facing both hanging part 4a of floor 4 of the enclosure car and the inner surface of enclosure car frame 2 so as to control longitudinal gap δ2 and traverse gap δ3 in the manner similar to the above described embodiment. According to the present embodiment, except that force of electromagnetic repulsion between the electromagnets, which face each other, is used, the same structural components as those of the above described embodiment are used. Here, whether force of electromagnetic attraction of electromagnets 10 and 12 or that of electromagnetic repulsion is used

is an issue of choice. Naturally, it is possible to use different methods depending on the longitudinal direction and the traverse direction.

[0018]

According to the levitation device with the above described structure, the levitation control is made at the time shown in Figure 4. Figure 4 is a timing chart showing the timing of the opening/closing operation of the door, that of the moving up and down of the enclosure car and that of the excitation period of the electromagnets. According to Example 1, considering energy saving, electromagnets 10 and 12 are not excited when the door is opened and closed. Instead, they are excited only when the elevator is moved up and down. According to Example 2, electromagnets 10 and 12 are excited in accordance with the timing of opening the door and excitation of the electromagnets is stopped when the door is completely closed. Here, in Example 2, although the timing of starting and stopping the excitation of the electromagnets is synchronized with the time when the door is completely opened or closed, the timing may be set in the middle of opening and closing the door. In either one of the above described cases, when the elevator is not in operation, electromagnets 10 and 12 are not excited to save energy.

[0019]

[Effects of the Invention]

As is obvious with the above described explanation, according to the present invention with the above described structure, it is possible to obtain the following effects.

[0020]

According to the invention as set forth in claim 1, wherein the floor part of the enclosure car and the side walls of the enclosure car are separably made and only the floor part is not contacted with the enclosure car frame by using an electromagnet, it is possible to maintain the state wherein the floor part of the enclosure car is not contacted with the enclosure car frame. As a result, it is possible to prevent transmission of mechanical vibration thereby providing an elevator with good riding comfort. Also, since the electromagnet only has to support the weight of the floor part of the enclosure car and the weight of passengers, which is applied to the floor part, the size of the levitation device is smaller than that of the device, which levitates the entire enclosure car, thereby saving energy.

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[0021]

According to the invention as set forth in claim 2, wherein an elastic body is further created between the floor part of the enclosure car

and the enclosure car frame so that said elastic body elastically supports the floor part when the floor part is contacted with the side of the enclosure car frame, when the elevator is not in operation and vibration is transmitted, the elastic body can support the floor part without using the electromagnet. Therefore, it is possible to save more energy in addition to the effect of the invention as set forth in claim 1.

[0022]

According to the invention as set forth in claim 3, wherein the electromagnet is comprised of a longitudinal electromagnet, which vertically levitates the floor part, and a traverse electromagnet, which horizontally separates the floor part from the enclosure car frame, in addition to the effect of the invention as set forth in claim 1, it is possible to securely separate and levitate the floor part from the enclosure car frame thereby demonstrably preventing transmission of the vibration.

[0023]

According to the invention as set forth in claim 4, wherein the electromagnets are positioned so that at least one of force of electromagnetic attraction and that of electromagnetic repulsion is used, it is possible to discretionally select each position of the electromagnets and their operational method in accordance with the mechanical positioning relationship between the floor part and side

walls of the enclosure car and the enclosure car frame and their dimensional relationship. Therefore, in addition to the effect of the invention as set forth in claim 1 or 3, it is possible to increase the degree of freedom in the design.

[0024]

According to the invention as set forth in claim 5, wherein an electromagnet control means, which controls electromagnetic force of the electromagnets, is created so as to control the gap between the floor part and the enclosure car frame, vibration transmitted to the floor part is actively prevented. Therefore, in addition to the effect of the invention as set forth in claim 1 or 3, it is possible to further prevent the vibration.

[0025]

According to the invention as set forth in claim 6, wherein a gap sensor, which detects a gap between the floor part and the enclosure car frame, is created and the electromagnet control means controls the electromagnetic force of the electromagnets in accordance with the detected output from the gap sensor so as to decrease the vibration of the floor part, the gap sensor detects changes in the gap and controls the electromagnets in accordance with the changes and decreases the vibration of the floor part. Therefore, it is possible to further increase the effect of the invention as set forth in claim 5 of preventing the vibration.

[0026]

According to the invention as set forth in claim 7, wherein a vibration detection means, which detects vibration of the floor part, is created and the electromagnet control means controls the electromagnetic force of the electromagnets in accordance with the detected output from the vibration detection means so as to decrease the vibration of the floor part, the state of the vibration is detected by the vibration detection means, and based on the detected state of the vibration, the electromagnets are controlled and the vibration of the floor part is decreased. Therefore, it is possible to further increase the effect of the invention as set forth in claim 5 of preventing the vibration.

[0027]

According to the invention as set forth in claim 8, wherein the vibration detection means is comprised of an acceleration sensor, it is possible to securely detect the vibration with a simple structure.

[0028]

According to the invention as set forth in claim 9, wherein a gain-phase adjuster, wherein the detected output from the vibration detection means is inputted, is created so that the output of the gain-phase adjuster is inputted in the electromagnet control means, it is possible to change the constant number by using the gain-phase

adjuster in accordance with the state of the vibration and control the electromagnets, which are in the vibration mode. Therefore, the effect of preventing the vibration is more significant than the invention as set forth in claim 7.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a view illustrating the outlined structure of the levitation device of the floor of the enclosure car of an elevator according to an embodiment of the present invention.

[Figure 2]

Figure 2 is a view illustrating the relationship between the enclosure car frame of an elevator and the levitation device of the enclosure car according to the embodiment.

[Figure 3]

Figure 3 is a view illustrating the structure of the pavement body of the levitation device of the floor of the enclosure car of an elevator according to another embodiment of the present invention.

[Figure 4]

Figure 4 is a timing chart showing the timing

[Figure 4]

Figure 4 is a timing chart showing the operational timing of the levitation device according to the embodiment of the present invention.

[Explanation of the Codes]

1: enclosure car

2: enclosure car frame

3: rope

4: floor of the enclosure car (floor part)

4a: hanging part of the floor of the enclosure car

5: side wall (side wall part)

6: bottom plate of the enclosure car frame

7: antivibration rubber

8: bottom part supporting plate of the side walls of the enclosure car

9: longitudinal bracket

10: longitudinal electromagnet

11: longitudinal gap sensor

12: traverse electromagnet

13: traverse bracket

14: traverse gap sensor

15: longitudinal acceleration sensor

16: traverse acceleration sensor

17: longitudinal gain-phase adjuster

18: longitudinal electromagnet control device

19: longitudinal gap commanding part

20: longitudinal adder

21: traverse gain-phase adjuster

22: traverse electromagnet control device

23: traverse gap commanding part

24: traverse adder

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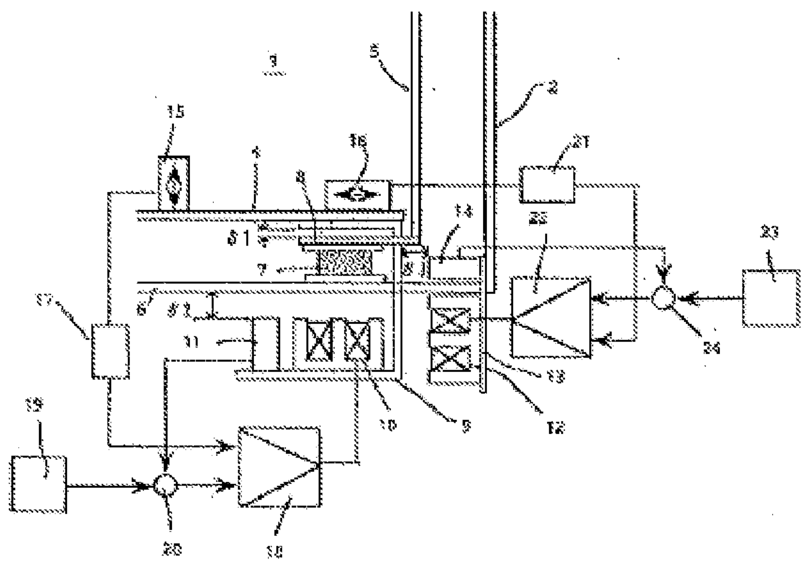
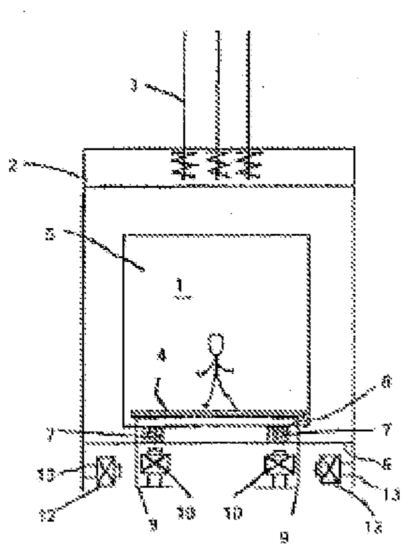
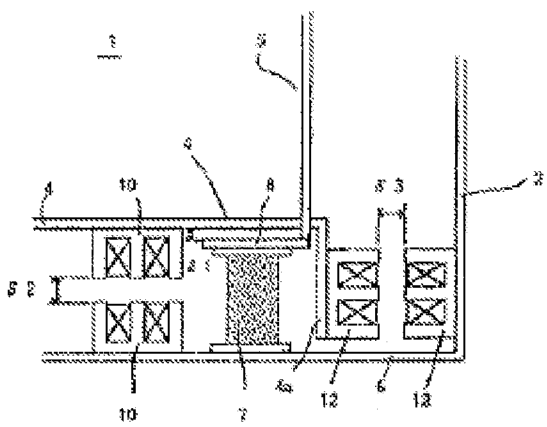
[Figure 1]



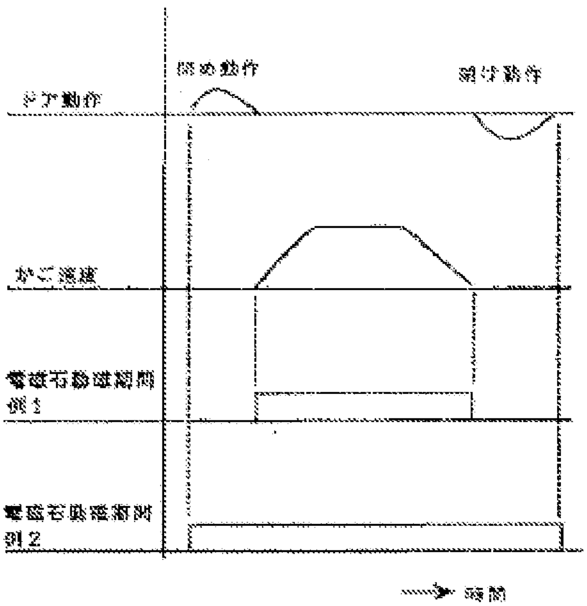
[Figure 2]



[Figure 3]



[Figure 4]



(from top to bottom, left to right)

Operation of the door: operation of closing the door, operation of opening the door

Speed of the enclosure car:

Example 1: period when the electromagnets are excited.

Example 2: period when the electromagnets are excited.

→ time